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S. HRG. 100-305

THE CHERNOBYL, RUSSIA, NUCLEAR INCIDENT

HEARING

BEFORE THE

COMMITTEE ON LABOR AND HUMAN RESOURCES UNITED STATES SENATE

ONE HUNDREDTH CONGRESS

FIRST SESSION

ON

REVIEWING THE CAUSES AND CONSEQUENCES OF THE CHERNOBYL NUCLEAR POWERPLANT INCIDENT

JANUARY 20, 1987

Printed for the use of the Committee on Labor and Human Resources

U.S. GOVERNMENT PRINTING OFFICE

78-970 WASHINGTON : 1987

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

S541-50

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THE CHERNOBYL, RUSSIA, NUCLEAR INCIDENT

TUESDAY, JANUARY 20, 1987

U.S. SENATE,
COMMITTEE ON LABOR AND HUMAN RESOURCES,
Washington, DC.

The Committee met, pursuant to notice at 10:00 a.m., in room SD-430, Dirksen Senate Office Building, Senator Edward M. Kennedy (Chairman of the Committee) presiding.

Present: Senators Kennedy, Cochran, Simon, Pell, Thurmond, Hatch, Stafford, Adams, and Humphrey.

OPENING STATEMENT OF SENATOR KENNEDY

The CHAIRMAN. We will come to order. My colleague and friend, Senator Hatch, who is the ranking minority member, is on his way and is necessarily detained, but will join us in just a few moments, but we will start in.

As recently as 50 years ago, the world knew nothing about nuclear energy or nuclear power or nuclear weapons or nuclear war. Today, all humanity lives in the shadow of the atom.

At Hiroshima and Nagasaki, we first learned of the awesome destructive power of nuclear weapons. Today, we live with the knowledge that vast arsenals of nuclear weapons can, in a matter of mere moments, extinguish all human life on this planet.

The fate of the earth depends upon the success of the effort to ensure that nuclear weapons will never again be exploded either by design or by inadvertence.

At Three-Mile Island and Chernobyl, we saw that nuclear power, even when tamed and harnessed for peaceful purposes, can also pose a catastrophic threat to the health and well-being of communities and entire regions.

Today, we live with the knowledge that a nuclear accident, no less than a nuclear attack, can jeopardize the lives of millions. This hearing is an inquiry into the causes and the consequences of the Chernobyl nuclear accident that took place on April 25, 1986, in the Soviet Union.

The hearing follows in the tradition of the hearings previously held by this Committee on the health consequences of the Three-Mile Island nuclear accident, a topic of continuing concern, and debate in this country.

I recall that this Committee also held hearings in the late 1970s on the long-term health effects of the early nuclear tests conducted in this country at the dawn of the atomic age.

I hope that in the near future this Committee can also inquire into other circumstances where innocent people have suffered from

the effects of radiation unleashed by nuclear explosions or nuclear reactions.

I know that Senator Hatch is particularly concerned about the welfare of citizens in Utah who suffered exposure to radiation during the nuclear tests in the atmosphere. I join him in that concern, and I want to assure him that this Committee will continue its efforts to examine the plight of victims of nuclear radiation.

It is a privilege to welcome a distinguished scientist from the Soviet Union, Academician Velikhov, who will present a report to us today on Chernobyl. Dr. Velikhov is the Vice President of the Soviet Academy of Sciences and is Chairman of the Energy Committee of the Supreme Soviet. He is one of the most highly respected nuclear scientists not only in the Soviet Union, but throughout the world. He is a close personal advisor to Secretary General Gorbachev on all matters relating to nuclear energy.

The Chernobyl disaster is the worst nuclear accident in human history. It will be decades before all the effects of this accident on both people and the environment are fully known. No one can be certain of the total damage already done, and there is even less certainty as to the problems that will be caused by the disaster years from now.

But we do know that 31 people have already died, that 209 others suffered serious radiation exposure, and that 135,000 Soviet citizens were evacuated from a radius of 18 miles around Chernobyl. It is my understanding that most of these people have not yet been able to return to their homes.We also know that the radiation spread across much of Scandinavia and Europe.

Dr. Velikhov was assigned the task of dealing with the Chernobyl crisis at a time when the magnitude of the accident was not fully known, and he presided over the investigation that took place afterwards that sought to determine the cause of the Chernobyl disaster.

We hope that Dr. Velikhov will present the findings of that investigation to the members of this Committee, for we are sure that there are many lessons to be learned from the Chernobyl experience not only for the people of the Soviet Union, but for all peoples who live and work in the shadow of nuclear power.

It is also a great privilege to welcome our other witness, Dr. Robert Gale. Dr. Gale is the Director of the Bone Marrow Transplant Division at the University of California at Los Angeles. He is also the Chairman of the International Bone Marrow Transplant Registry.

When the magnitude of the Chernobyl disaster became known in the West, Dr. Gale, with the help and personal support of Dr. Armand Hammer, flew directly to the Soviet Union to see what he could do to assist the Soviet medical authorities in their efforts to treat those individuals most seriously exposed to radiation.

Through Dr. Gale's efforts and Dr. Hammer's support, medical equipment was transported to the Soviet Union and a medical team was assembled which performed 13 bone marrow transplants.

We look forward to hearing from Dr. Gale about his experiences with the Chernobyl nuclear accident, and we hope to hear his views about the consequences of that event with respect to human health.

We know that Dr. Gale took "the red eye" from the West Coast and just arrived in Washington this morning, but we look forward to hearing from him, nonetheless, in just a few, short moments.

Let us turn first to Dr. Velikhov. I know that you have prepared a report, and I would hope that in the course of your presentation we would cover the following areas.What we really want to know is what happened, how did this accident occur, and why.

We are interested in what was done to deal with the threat of contamination both to the people and to the environment; is the disaster over and what does the future hold; what lessons can we learn from this tragedy not only for the Soviet people but for all people who live in the shadow of nuclear power? That is basically what we are interested in being able to learn as a result of these hearings this morning.

We want to extend a very special welcome to you, Dr. Velikhov. We know that you have made a special trip from the Soviet Union to be with us here today and to talk with us about these matters, and we appreciate your willingness to share this experience with us.

Senator Cochran, did you have a statement?

Senator COCHRAN. Mr. Chairman, I do not have an opening statement. I appreciate your recognition of me. I look forward to hearing the witnesses.

The CHAIRMAN. Dr. Velikhov, maybe you would start off by indicating a little bit about your own scientific background and then follow that with your testimony.

STATEMENT OF ACADEMICIAN YEVGENY VELIKHOV, VICE PRESIDENT, U.S.S.R. ACADEMY OF SCIENCES

Dr. VELIKHOV. It is a privilege for me to serve as a witness in the United States Senate and in this distinguished Committee. I will try my best.

I am a specialist in nuclear fusion, and most of my life I have worked in nuclear fusion, which is, of course, in a completely different stage from nuclear fission.

In connection with Chernobyl, it is, I think, an interesting story how I am involved, because I received a telegram from Professor Frank von Hoepel from Princeton University, who advised me to speak to our authority—it was, I think, April 28th—to use the iodine pills to prevent damage from iodine.

The CHAIRMAN. This was in April of 1986.

Dr. VELIKHOV. Yes. After this, I called the Deputy Chairman of the Council of Ministers, and he asked me to go to the government commission. In this commission, I have information we already use these pills, and I am involved in discussions, and after this, the Chairman of the Commission, Premier Minister Ryzhkov, sent me to Chernobyl in the chief team to help the chairman of this team, Vice Chairman of the Council of Ministers, to study the situation and to make some scientific advice.

The Chernobyl accident of course had a very big influence on the development of——

The CHAIRMAN. This was a day or so after the accident; is that correct?

Dr. VELIKHOV. Yes. I went to Chernobyl on May 2.

The CHAIRMAN. You went on May 2, and the accident was on April the 26th.

Dr. VELIKHOV. The accident was on April 26th. And of course, this accident had a big influence on the development of nuclear energy and the energy program in general, but this accident has, I think, great importance to our understanding of how to deal with the very complicated technological system in which we live today and we wish to live tomorrow—this system in industry, in the military system, and in some ways, the political international system.

And in such case, I think this hearing today is extremely important.

First of all, I will give you some information. I think to date all information is available in the presentation in the Vienna Conference and in many publications, especially in American newspapers. But I will give you very brief information, and after that, answer the questions.

At Chernobyl, there were four nuclear reactors, 3,200 megawatts thermopower each, graphite-type. These reactors were in operation, and of course, these reactors had all systems of safety, many systems of safety, and these systems are designed to cope with such types of situations, so-called plant situations—situations, of course, which do not take into account the possibility of such multiple errors and deviations from procedures, which happened on April 26th.

The personnel in the reactor site were 176 people in shift and 268 workers on-site.

On April 25, the shift planned to stop the reactor for the medium service. Without a shutdown, it was planned the testing of turbine generator Number 8, and the day of the testing, to separate the turbine generator from weapons supply and use the inertia of the rotor to study the feeding mechanism of the reactor without external power supply.

With the proper order of testing, and with the additional measure of safety, such testing was legitimate in a working nuclear power station and was performed before. But this requirement was not taken into account in the working program of testing of turbine generator Number 8 in this specific program. This program not only did not take into account the additional measure of safety, but it was a requirement to shut down the special system of cooling of the reactor in the accident. And in the time of the four hours, the reactor was working in the condition of lower safety.

This program was not discussed in a proper way with the authorities and with the personnel in charge of safety and physics of the reactor. And in such case, the personnel had no real knowledge of the possible danger and consequence and were not really ready for this, and the personnel made important deviations from the program.

The program of testing of the reactor was planned to work in the level of power of 700 to 1,000 megawatts. But the operator made a mistake, and the power dropped to nearly 30 megawatts. Only after a few hours was it possible to stabilize the power at the level of 200 megawatts, but it was lower than planned, and in this process it decreased the operational level of measurement of reactivity. And

in such case, the safety system was noneffective because the level of reactivity dropped, and the reactor went into the condition which is very difficult to handle. There were first two very important errors.

After this, the operator continued to make disturbance in the system. He tried to stabilize the system but made big disturbance. He increased the water flow—this was prescribed by the program, and sometimes it shut down the safety system, which is to block reactor, if it is the signal of stopping of two turbine generators.

In such case, this shutdown of this additional safety system, as a consequence, the operator had no possibility to automatically—there is a consequence of no possibility of automatically stopping the reactor.

It shut down the safety system, which is designed to stop the reactor if the level of water and the pressure of vapors is not in the proper corridor. This operator made this because it was very difficult for him to handle the reactor in such an unstable condition.

Altogether, there were six very important errors, and had the operator not made these errors, nothing would have happened.

The CHAIRMAN. At this point, I would like to see if I understand. This was basically a process and a procedure and a test to evaluate some of the safety measures in that particular plant. And the personnel who were involved in this process or procedure were not fully aware, as I understand it, of the potential dangers that might result from the steps that they were taking as they were moving towards the test.

And what you have just mentioned now is that there were a number of safety procedures which were in place, but in order to test this particular reactor those safeguards had to be either turned off or cancelled out. And a series of human errors took place; six human errors took place which cumulatively resulted in the accident.

This was really an impossible circumstance, as I understand it, based on the the law of averages.

Dr. VELIKHOV. Unthinkable.

The CHAIRMAN. Unthinkable; unthinkable that such a series of human errors could take place. We often see that there are fail-safe systems built into technology and into nuclear program both in the Soviet Union and in the United States. And, as I gather from your testimony, really, the unthinkable, the unimaginable, the unpredictable occurred. There were a series of human mistakes by individuals who did not understand what the significance of all six of those actions would be, and as a result of those errors, the accident occurred.

Is that correct?

Dr. VELIKHOV. Yes.

The CHAIRMAN. Okay. Would you continue?

We want to have your full testimony, but could you tell us what those six steps were just very briefly?

Dr. VELIKHOV. What were the six?

The CHAIRMAN. Yes, just very briefly.

Dr. VELIKHOV. First, it was the decreasing of the reactivity margin and working in the very low level of power; in such case, the accidental safety system was ineffective.

After this, they increased the flow of water, cooling water.

After this, blocking the safety system for thermal signals; and blocking the safety system, which shuts down the reactor in the case of the stopping of two turbine generators.

And as I said already, the automatic cooling system of the reactor was shut down.

Altogether, there were six mistakes.

The CHAIRMAN. All right. Now, they had fires as an initial reaction, early in the morning, around 1:20 in the morning, and then a further fire after that, another explosion after that. And, as I understand it, some days later, you were asked to go to Chernobyl, and you assumed responsibility for the general situation, both the clean-up and to give a report.

Can you describe to our Committee your travel to Chernobyl? What did you see as you first approached Chernobyl? Can you give us a little bit of a feel for what the land was like, what the site looked like when you saw it, what your own feelings were at the time that you first viewed it, and how did you get there?

Dr. VELIKHOV. Okay. Maybe first I will finish.

The CHAIRMAN. Yes, fine.

Dr. VELIKHOV. After the power went off in the reactor, the operator on the order of the supervisor tried to put the shutdown system, but this system was not effective, and what happened was a very fast increase of power production. With this increase of power production, the reactor lost the cooling water, and the fuel super-heated and the fuel element was destroyed, and fuel mixed with the cooling water. It started very fast boiling, and there was really no blast, but a thermal blast—the big pressure of vapors put out the debris of part of the reactor core, and this very hard reactor core dropped on the roof.

After this, the pressure from the pumping system put water in the reactor, and we had additional thermal blast, which put an additional part of debris and fuel elements and hard graphite outside.

This was the cause of the fire. This fire was very important evidence, because this fire made a danger for reactor Number 3, Number 1 and Number 2, first of all, Number 3. The firemen stopped the fire after five hours of struggle.

After this, the government commission was already going to the site, and it was the decision to stop the emission of radiation, but put the special blanket on the reactor. The other possibility was to use the helicopter fleet. In a number of days, the helicopters put on the reactor 5,000 tons of different sand, lead, boron, and covered the reactor and stopped the radiation emission and stopped the fire.

The CHAIRMAN. How many helicopters were you using?

Dr. VELIKHOV. I do not know the exact number, but I think it was hundreds of flights per day.

The CHAIRMAN. Hundreds of flights per day, more than we would certainly have out of airports here.

And as I understand it, they could not get very close to the site, either, because it was producing so much radiation.

Dr. VELIKHOV. Yes.

The CHAIRMAN. So they had to drop this sand——

Dr. VELIKHOV. Eighteen kilometers from the site; the helicopters had their own base near Chernobyl.

The CHAIRMAN. But the helicopters themselves were facing seven difficulties of radiation, weren't they, and vapor.

Dr. VELIKHOV. Yes.

The CHAIRMAN. So they had to drop their sand——

Dr. VELIKHOV. Very fast.

The CHAIRMAN [continuing]. At some altitude away from the fire itself; is that correct?

Dr. VELIKHOV. Yes.

The CHAIRMAN. It was difficult.

Dr. VELIKHOV. It is a level of 200 meters, generally, because at such level it is more than 100 roentgen per hour radiation level, and the condition was very severe.

The CHAIRMAN. So approximately 600 feet; okay.

Dr. VELIKHOV. And in such case, it was a very difficult operation. But it happened quite well, and most of the sand dropped on the reactor.

After this, I went to the site on May 2, and I visited the reactor by helicopter. I saw the around, the empty village, empty town. And the power station was surprisingly intact, in general, all the buildings. Really, only the building of Number 4 was destroyed. But from the scale of the accident, from the consequences around, the scale or the result of the blast was very small, the mechanical result of the blast. My feeling was that only the radioactive fall-out made this accident so severe.

The next step, the next operation, was to study what happened with the fuel under the blanket, because it was two processes. One process was the product of decay was separated from the fuel by the high temperature and escaped; at the same time, the fuel super-heated and penetrated down through the concrete and steel.

In such case, we started to make the special——

The CHAIRMAN. Now, if I could just go back a step. When you flew there in the helicopter, you commented that there was very little physical damage, generally, in the power plant other than these two buildings; but you say that you saw a village that had been evacuated.

All the people had been removed by this time; is that correct?

Dr. VELIKHOV. Yes.

The CHAIRMAN. How many thousands of people had been removed?

Dr. VELIKHOV. From the Prepich town in the first ten-mile zone, it was near 50,000; but altogether, it was 135,000. Some part returned afterward.

The CHAIRMAN. So 135,000 were moved.

Dr. VELIKHOV. And today, 120,000 people have been removed permanently and live in another place.

The CHAIRMAN. And those people who moved, did they take their belongings with them?

Dr. VELIKHOV. Yes, some belongings and livestock.

The CHAIRMAN. They took their livestock with them, too. How were they moved? What kind of transportation was made available to them to move them?

Dr. VELIKHOV. It was a two-step evacuation. The first step took place on the 27th, and it was prepared in the night from the 26th to the 27th. They used thousands of buses to remove the people from Prepich and villages in the zone of ten kilometers.

The next evacuation took two days, May 2 and May 3, with the evacuation of all people and livestock from the 30 kilometer radius zone.

After this, there was some evacuation of some parts outside of this zone, connected with a more high level of radiation.

But at the same time, in the building of the reactor, we try to study what happened with the reactors themselves.

The CHAIRMAN. All right. Now, as I understand, the roof had fallen in—is that correct—onto the reactor?

Dr. VELIKHOV. Not roof, but blanket; 5,000 tons of sand and other materials, were dropped on the reactor.

The CHAIRMAN. Okay. And you were concerned about what would happen if the reactor melted through the concrete and steel and got into the water table that was just underneath it.

Dr. VELIKHOV. Yes.

The CHAIRMAN. What would be the result if that happened? How much of a risk was there that it might happen? First of all, what would have happened if that had taken place?

Dr. VELIKHOV. Of course, we were afraid if the very hot debris of the reactor interacted with the water, we would have another heat blast with the injection of new radioactive material.

The CHAIRMAN. And that would have meant that radiated steam went up into the sky.

Dr. VELIKHOV. Yes, injection of new radiated steam, yes.

The CHAIRMAN. And they were concerned about that.

Dr. VELIKHOV. Our first goal was to put water out of this vessel under the reactor. It was very difficult to do, and the technicians and engineers made this, because it is highly-radiated water and a highly-radiated environment.

The CHAIRMAN. You were told, as I understand, that that platform would only hold for a certain time, were you not, before it would go down into the water? Did your engineers indicate to you that after a certain period of time, that the floor, so to speak, above the water might collapse? Did they tell you that by the middle of May or so, it might give way?

Dr. VELIKHOV. It was a possible development of evidence. Of course, it has not happened, and we are happy; the cooling of this platform by the air flow was much higher than we estimated at this time. But we were afraid of such a development, and our first goal was to put water out of these vessels.

Our second goal was to install the special heat exchanger under the basement of building, because we were afraid of the future developments with the high-temperature core. And this was a very big job because the miners had put the 136-meter-long tunnel under the old buildings of Number 2 and Number 3 and built from this tunnel under the basement of the reactor the special heat exchanger. This is a very important part of the work.

The CHAIRMAN. How many people now were working on trying to quiet the fire or put the fire out and to do this kind of work of

evacuation? Are you talking about one thousand, or are you talking about tens of thousands of workers?

Dr. VELIKHOV. We are talking about tens of thousands altogether.

The CHAIRMAN. Tens of thousands of workers. And that includes what—army, workers from other plants? What does that include?

Dr. VELIKHOV. It includes workers from other plants, miners, technicians, engineers, scientists, army, soldiers, all together working inside of the station, in the disactivation of a certain kilometer zone already.

What happened after this was we started to study what happened with the construction of the building because our next goal was to rebuild the concealment system, the concrete tomb under the reactor, to conceal the reactor. And in such cases, we started to study the conditions of construction of the building and the condition of the fuel and the debris of the reactor.

It was quite a difficult job, because it was necessary to put instruments. We put the instruments underneath the reactor to measure the temperature and radiation level, and we put instruments above the reactor from a helicopter and installed barriers, to measure the radiation and temperature of the reactor.

The CHAIRMAN. What happened to the other instruments that were there to measure the radiation in the reactor?

Dr. VELIKHOV. The instruments which were installed in the normal operation, we have no access to the room where we had the old instruments connected.

The CHAIRMAN. You could not use any of those?

Dr. VELIKHOV. No, we are not using those instruments.

The CHAIRMAN. None of those meters or any of those measuring devices could be used; you had to implant other kinds of measuring devices, both underneath the reactor as well as on top; is that correct?

Dr. VELIKHOV. For us, it was necessary to install a whole new set of instruments, around the reactor, underneath and on top of the reactor. And we did this in a very unfriendly environment, because the level of radiation fluctuated and was very high, from 10 roentgen to 100 roentgen.

The CHAIRMAN. Could you tell us what was the effect of this radiation on machinery, on electrical machinery, when it was attempted to be used to deal with the crisis?

Dr. VELIKHOV. One of our approaches to deal with the debris of the reactor is to use remote control machinery, and some countries provided us with remote machinery.

The CHAIRMAN. Robot-controlled machinery.

Dr. VELIKHOV. Robots, yes. But only after some development and improvements was it possible for us to use these robots.

I think today——

The CHAIRMAN. Why was that necessary that you consider or use remote-control robots?

Dr. VELIKHOV. Because the debris of the reactor was very highly-radioactive, and it was impossible to use any manpower. It was possible to use only remote-control robots.

The CHAIRMAN. And what happened to those remote-control robots?

Dr. VELIKHOV. Many of those robots did not work very well in this highly-radioactive environment and very difficult conditions. And I think one of the very interesting fields of our possible future cooperation is to develop such a type of robot together for the future.

The CHAIRMAN. Part of the problem as well was the fact that the radiation affected the electronic systems of these robots, is that right?

Dr. VELIKHOV. Yes.

The CHAIRMAN. And it effectively neutralized those systems so they were incapable of performing.

Did you expose yourself to this radiation at any time? Did you enter the reactor itself?

Dr. VELIKHOV. Yes, of course. Generally, I think the people who were working in the vicinity of the reactor—engineers, technicians—were working under strict medical control, and our level of exposure was near 20-30 rems in general. And after this, we stopped working and changed shifts.

The CHAIRMAN. Just for the record, how much of a danger is 20 or 30 rems?

Dr. VELIKHOV. From my personal understanding—and I am not a physician—but from my personal understanding the danger is not very big. The immediate danger is zero, and the danger for the future development of cancer and so on is very small; it is in the errors of our knowledge. Really, it is much more dangerous if you smoke.

The CHAIRMAN. If you smoke—no one does that around here. [Laughter.]

Tell me, a lot of those areas had higher concentrations of rems, is that right? There were some "hot pockets" that had what level—several hundred rems?

Dr. VELIKHOV. Yes.

The CHAIRMAN. And others were cooler or had less. And you were exposed to a fair amount of radiation. Tell us about what you do after you are exposed. What do you have to do with your clothes, and how do you deal with it yourself, in terms of a shower?

Dr. VELIKHOV. I think the possibility to work under medical control and without consequence is only possible because we have facility to clean ourself. It is a standard facility of a nuclear power station, with the hot shower. We change clothes completely, and we change some number of instruments, because many instruments are impossible to clean up after such work.

The CHAIRMAN. And so you cannot use the clothes again?

Dr. VELIKHOV. No, no; not clothes, not personal belongings. Everything was finished.

The CHAIRMAN. And how long did you used to stay in the shower to try and scrub yourself?

Dr. VELIKHOV. I think it was half-an-hour, maybe tens of minutes, to clean yourself.

The CHAIRMAN. That is scrubbing all of your skin, each time that you were exposed to this.

Dr. VELIKHOV. Yes, because it is not only exposure to radiation, but the main problem was the dust and such type of contamination. And in such case, I am a little skeptical of the proposals of

some scientists who say in the case of nuclear war, it is possible to just use the shower to clean oneself from radioactive fallout. I think it is only possible in the very special condition where all the systems are in operation.

In the real conditions of nuclear accident, you have no chance to survive because you have no chance to change clothes, no chance to shower, no chance to clean yourself. And this is a very big difference between the situation in which you have a very small damaged part, and full access from outside, and all facilities in operation.

The CHAIRMAN. Now, Academician Velikhov, you have described your impressions when you first visited Chernobyl the steps that had to be taken when you entered the reactor.

Could you describe to us a little bit about the steps that were taken by all of these workers, the tens of thousands of workers, to clean up the site? How much topsoil, for example, had to be removed? How many buildings did you have to decontaminate?

Can you give us some idea of what that would be?

Dr. VELIKHOV. I can give you some estimation. First of all, I think a very important result of seven and a half months is the building of the protected structure for the damaged power unit. This protection structure makes it possible to put in operation the first and second power units.

This complex was extremely difficult, and it is a unique design, because it was only possible to build after we checked the situation for construction after thermal blast, and we built all the buildings in the environment of very high radiation levels. In such case, it was a unique operation in terms of the destroyed power-generating units, in difficult conditions.

This new structure was filled with the old diagnostic instruments and monitoring facilities. After the immediate technology was used in construction, already 300,000 cubic meters of concrete were laid; 6,000 tons of metal structure were assembled. At the same time, it was a measure to decontaminate the buildings of Unit 1, Unit 4 and Unit 3—which is a very big job.

Outside of the building was the problem of decontamination connected with the removal of the soil, and hundreds of square meters of soil were removed. But at the same, we were afraid of the flow the radioactive dust by rain to rivers. In such case, we covered thousands of square meters with the plastic layers which were produced onsite to fix the radioactive fallout.

The CHAIRMAN. Now, as I understand it, you are talking about thousands of cubic feet of concrete, hundreds of thousands.

Dr. VELIKHOV. Three hundred thousand cubic meters of concrete.

The CHAIRMAN. As I translate it—and I hope our math is correct up here—that is about a 20-story building.

Dr. VELIKHOV. Sixty-one meters high.

The CHAIRMAN. So 180, 200 feet high. And that was with concrete, in order to contain this. And you say that hundreds of thousands of square meters of topsoil had to be removed. How deep?

Dr. VELIKHOV. Ten centimeters.

The CHAIRMAN. Ten centimeters deep. So what we are talking about is a number of square kilometers, a number of square miles of topsoil that was removed. And you are talking about plastic cov-

ering; as I understand, that was something that the French government participated in; is that right?

Dr. VELIKHOV. The French proposed to us to use this plastic. But it was a very small amount, and at the same time, we were already organized to produce a big amount in place.

The CHAIRMAN. I see. Well, and you covered a number of different surfaces. What were those—buildings——

Dr. VELIKHOV. Machinery.

The CHAIRMAN [continuing]. And machinery. And then you would collect the debris, the fallout, on those facilities. So you had, I guess, several square kilometers of area that were covered with the plastic covering; you had a number of square kilometers in which ten centimeters of the topsoil had been removed; and you had a very sizeable amount of concrete that was used to block the leaching of radioactive groundwater into the river and to contain the site.

Is that correct?

Dr. VELIKHOV. Yes, but that is not the full story. The full story is that we built a special concrete wall in the soil to separate the groundwater from possible penetration into the river. This concrete wall surrounded all of the nuclear power station and had a depth of 15 meters.

After this, we drilled hundreds of holes, drainage holes, to control and put out the contaminated water. And after this, we built special surface dumps, tens of kilometers of surface dumps. This, together with the action that we put in the first months after the accident—we stopped the rain by seeding the clouds—altogether gave us very important results. After the first days, we never had any level of contamination in the drinking water in Nyeper or in Prepich or in the water supply lake.

After this was the special measure to decontamination of the villages and buildings. We decontaminated 60,000 buildings and 500 villages, clean-up, and this decreased the level of activity seven to ten times.

After this, we worked with the soil and with the forests, with forests mostly to prevent forest fires.

Altogether, this gave us the possibility to start operation of this reactor.

The CHAIRMAN. How did you remove the topsoil? As I understand, 100,000 square meters is close to 1,000 acres.You might not be familiar, but Yankee Stadium is about 3.5 acres; the RFK Stadium is about 3.5. We are talking about 1,000 acres here where you removed topsoil.

How did you do it? Did you do it with bulldozers?

Dr. VELIKHOV. Bulldozers, yes. We removed it by bulldozers and put it in special metal containers, and we put these containers in special storage near Units 5 and 6. In such case, we put this soil in a special, safe place.

The CHAIRMAN. Those Units 5 and 6 are the neighboring reactors, is that right?

Dr. VELIKHOV. Yes.

The CHAIRMAN. And there are storage areas available there?

Dr. VELIKHOV. Yes.

The CHAIRMAN. To take all of this material?

Dr. VELIKHOV. Soil, yes; soil and debris of the reactor which we found outside of the buildings.

The CHAIRMAN. And then what about the plastic covering; you gathered that up afterwards, too, did you, and brought all of that plastic covering in?

Dr. VELIKHOV. Yes.

The CHAIRMAN. And has that gone into the same storage?

Dr. VELIKHOV. Some part of the debris, we stored in the building which is Unit 4; but mostly, we stored it in special storage.

The CHAIRMAN. OK.

Dr. VELIKHOV. After this we organized at the same time, in parallel, the measurement of nuclear contamination in the building, outside the building, in this 30-kilometer zone and in the much wider space of the U.S.S.R.

We used planes, helicopter and field monitoring stations. The problem was that we needed exact knowledge of the level of radiation, especially since the fallout was very non-uniform, and in such case to make a detailed prediction where it was necessary to evacuate people and where it was possible to re-evacuate. We needed exact knowledge of what was happening with radiation levels.

The CHAIRMAN. What we have here is tens of thousands of individuals working and taking the most extraordinary steps to try and guard against further danger to the population—the immediately-exposed population and those in the neighborhood as well as in Europe—using the latest in technology that is available to your government and a number of governments around the world who indicated that they wanted to help and assist you in dealing with this.

And we are just talking about one accident in one country, and the extraordinary steps of tens of thousands, getting into 40 to 50 thousand people, working to clear this up, and thousands of acres of topsoil having to be removed, and massive concrete structures being utilized to try and guard against the further dangers and threats to the health and well-being of members of the community and of the world, in a system, as I understand it, that was considered to be fail-safe—nothing could go wrong.

And one of the lessons I think you have to draw from this experience is that no matter how fail-safe any system, no matter how many checkpoints you have and how many things have to be replicated and buttons have to be pushed before something wrong can happen, here was a situation where those things actually did happen. There was a series of events, as you mentioned, that resulted in this accident—some six mistakes which taken together, cumulatively, resulted in this accident—somethings which those who designed and operated the plant could not possibly imagine could take place.

I am sure there will be those who will read the record and say, well, there could be differently-designed structures. We are not experts, clearly, in the design structure of nuclear plants. There may be other, better ways of dealing with safety. The fact remains that nothing in this world is absolutely safe. The potential dangers of nuclear power are so awesome in terms of possible threats to popu-

lations that it gives us a moment of pause, certainly, when we think that such power might be used in conflict, in a war.

Would you please continue? I would be very interested, Dr. Velikhov—and I know I have taken a lot of time in making the case—I wish you would share with us your own sense of whether the cleanup now has finally come to a halt. Has all been done that can be done, or is there still a potential for concern among the Soviet authorities about what might happen in, say, the springtime?

Dr. VELIKHOV. Of course, the concealment of Unit 4 is finished, and there is not any danger of any injection of radioactive substance. Of course, we put very strict control and good control systems inside of this building. But it is because we need to control the ventilation system, the filter system; we need to control the environment inside of the building.

From the point of view of the decontamination, we are quite happy with the results. But our plan is to continue the decontamination, especially in the soil. With the deep-plow technology, it is possible to do very effective soil decontamination.

We are quite happy with the results in the reservoirs with the water. But of course, there is some problem with what happens when the floods start in the spring, because in such case the flow rate in the Prepich region—it is very flat marsh—increases ten times. We do not predict any dramatic results, but of course, we have prepared for this; we have built a special system to deal with this, and we wait for this. And after this, our plan is to decontaminate as much as possible, and put the soil and put the region in working condition, where it is possible to live again.

The CHAIRMAN. There is one feature about this whole tragedy that, as I understand it, has not yet been completely resolved. It is the potential health hazards and dangers when, in the spring, you get very considerable rains, and the increase of the flow of water by some ten times, of surface water, and what that means in terms of the flow of radioactive leaves and other contaminated debris into the rivers and on into other parts of the country.

That is something that you have to be concerned about, I imagine.

Dr. VELIKHOV. Yes, we are concerned, of course, and we have prepared for this. We have prepared with different measures—to build the dams, to build the special traps in the reservoirs, and to organize this special bypass system, temporarily, because the floods are a very short time, and a temporary bypass system for providing the principal towns with water.

In such case, I think nothing will happen, but of course we are concerned with the spring floods. After this, our goal is, as I say, to re-evacuate some number of people, because people wish to live in this place.

We already have made quite a big measure. We have built, I think, 12,000 houses for these people who have been evacuated—new houses—we have built already 200 social and supporting facilities. We have given practically all these people the possibility to work and to educate their children. But some number of people, of course, wish to return. And we continue our efforts of decontamination of the soil and of the village and the environment.

The CHAIRMAN. So what do you think will happen to those people? Will they be able to return to their villages or not? Will there have to be a permanent relocation, or will some of them be able to return? You mentioned 135,000.

Dr. VELIKHOV. Some small number have already returned, and we hope to increase this number. But of course, it is difficult to say because in the central region, the contamination is quite high, and we have no reason to re-evacuate the children and families. In such cases, it is difficult to predict today what percent of re-evacuation is possible.

The CHAIRMAN. How long will it remain dangerous, do you think?

Dr. VELIKHOV. Theoretically, the danger remains very long, because today's cesium, which is the principal element today, has a lifetime of 70 years. But of course, it is necessary to take into account the wash-out effect and the contamination effect. In such case, maybe the situation is going to be much better than we predicted before.

The CHAIRMAN. How large a geographical area are you talking about now?

Dr. VELIKHOV. Principally today, it is the same area, 30-kilometer radius, 1,000 square kilometers. But of course, it is not a circle, because it depends on the condition; the meteorological conditions were quite different in the first days, and we have non-uniform distribution of fallout.

The CHAIRMAN. So we are talking about a 30-kilometer radius from one nuclear plant that has real danger in terms of supporting human life and the well-being of children, that is contaminated at this time, with the uncertainty about when it will be available to those families in the future; is that correct?

Dr. VELIKHOV. Yes.

The CHAIRMAN. Dr. Velikhov, I would finally like to ask you just a couple of questions which I think the American people have on their minds. That is, why was there a reluctance by the Soviet authorities to share with the world community the information that was developed on the seriousness of the problem, early? Why was there some reluctance, apparently, to share that?

You have been very frank and forthcoming in your presentation today. And we are aware of the presentation that was made in Vienna, which was very complete. But in the early period of the development of the disaster——

Dr. VELIKHOV. My personal view is quite simple. I think most of our interest was connected with the internal developments, because first of all, we informed the people in Prepich the same day; we informed the people in this region in the next few days.

But I agree with you that for the future, I think it is very important to have international agreements, which we have already signed, to share information immediately, to have the special geographical point where it is necessary to measure continuously the radiation level, to have the radiation bank—all these agreements, I think, are extremely important. And for the future, I hope—I am sure—this delay will be avoided by such measures.

The CHAIRMAN. What do you think are really the principal lessons of Chernobyl, from a human point of view and from a technical point of view?

Dr. VELIKHOV. One lesson, I think, which is very practical is how to deal with the reactor which is working today. We have already made technical use, and we have increased the operational requirements, we have increased the management quality, and we have organized a special system, a special Department for Nuclear Power to deal with this.

At the same time, I think it is very important to have international cooperation. In the field of nuclear energy, it was not very easy to have such cooperation before, and it is a pity to wait for such an accident to start real cooperation. But today, I think there is general understanding of the importance of cooperation, to share experiences, to help each other and to develop much more safe nuclear power plants, because for our understanding, we have no choice—it is necessary for us from economical considerations to develop nuclear fission economy.

At the same time, I think it is very important to start more vigorous efforts to develop new sources of energy. I am personally very interested in cooperation in fusion, and as you know, our General Secretary, Mikhail Sergeyevich Gorbachev has proposed to the American government to cooperate in this. And I hope we will solve this problem. It is very reasonable at such time to start a much more vigorous program to develop new sources of energy—fusion, alternative sources, economy of energy. And there is another lesson, one very important lesson, I think, is how we deal with the very complicated and unstable systems, because in many cases, many high-technology systems have an instability region, and in such cases, the lesson of Chernobyl is to pay much more attention to interaction between man and such very complicated systems.

Especially, I think it is very important to avoid the wrong feeling of safety. Sometimes we have a wrong feeling if for some number of years, everything is okay; we think it is continuous forever. But it is necessary to avoid such an extrapolation and to sometimes start thinking about the unthinkable. Especially, it is very important in such complicated systems as the weaponry systems which we have today and that I hope we will not have in the future, but we have planned for the future.

I think it is a very important lesson of Chernobyl. My personal feeling is, after my personal experience with Chernobyl, that if we wish to avoid real disaster, which we have no capacity to deal with, there is only one way—to at the same time, in a reasonable time, completely eliminate nuclear weapons.

The CHAIRMAN. I think that is an excellent summary, particularly the interplay of the danger, potential danger, of human beings with high-technology that can result in disasters.

Our colleague and friend, Senator Hatch, is here. We also have Senator Thurmond here, who is a member of the Armed Services Committee and the Human Resources Committee, and former President pro tem. We also have Senator Cochran here, from Mississippi, and Senator Simon, from Illinois. You will see a number of our other colleagues will come in and have to leave. Senator Pell,

who is Chairman of our Foreign Relations Committee, was here earlier for the bulk of the presentation.

Senator Hatch?

OPENING STATEMENT OF SENATOR HATCH

Senator HATCH. Dr. Velikhov, welcome to our country and welcome to our Committee. We are very happy to have you here and appreciate you taking the time to testify here today. I do have a couple of questions I would like to ask.

In view of the accident at Chernobyl, Dr. Velikhov, does your government still expect to expand the use of nuclear energy in the Soviet Union, and does it still intend to continue to build nuclear reactors?

Dr. VELIKHOV. Yes—because we have no choice. If we take into account, as an example, we have plenty of coal, we have natural gas, we have oil. But if we take into account our projected development, we need energy, especially because of the transportation problem in the U.S.S.R. And if you take into account the cost risk of other options—for example, coal—this risk is quite big, much bigger than nuclear, in some ways.

Senator HATCH. You are saying the use of coal is a bigger risk than nuclear power?

Dr. VELIKHOV. Just in the counting of how many people died from this, from one area of energy, or from transportation, from mining. The other thing is environmental pollution; it is necessary to take into account environmental pollution.

But in any case, I think Chernobyl made a change in some slowdown of our program, because we need to find additional technical means, additional organizational means, additional discussion of the site choice. And it is necessary, of course, to pay much more attention to developing the new generation of nuclear reactors.

Senator HATCH. I have been led to believe that the recent five-year plan calls for nuclear power generation to double, so that it ultimately provides about 20 percent of the total Soviet electricity needs. Is that correct?

Dr. VELIKHOV. Our plan is by the year 2000 to increase five times the nuclear power capacity, and mostly to build new nuclear power plants in other parts of the country.

Senator HATCH. I apologize to you if somebody else has asked this question. I had to be necessarily absent for the first part of this. But it has been estimated that the food and environmental losses to Western Europe due to the accident at Chernobyl were estimated at $500 million, including $100 million in West Germany and $40 million in Sweden.

Now, Dr. Velikhov, is your nation, the Soviet Union, willing to accept responsibility, legal responsibility, for the accident and, where necessary, to compensate Western Europe for the damage caused to human life, their livestock, and of course their environment?

Dr. VELIKHOV. First of all, I think it is necessary—these are some new numbers for me, especially the damage in life; I do not know exactly what you mean. From the point of view of the prevention

of losses and compensation, I think it is necessary to establish a new regime and international rules to organize this process.

To my knowledge, today there is no international law in the framework of which it is possible to solve this problem.

Senator HATCH. Dr. Velikhov, I was wondering if you would comment on how the work crews who did the cleanup were actually assigned—and who were the people who were assigned to the dangerous task of cleaning up the accident? How were they chosen? What steps were taken to protect and monitor their health?

Dr. VELIKHOV. Excuse me. Would you repeat?

Senator HATCH. Yes. How were the people chosen who were responsible for the dangerous task of cleaning up after the accident? How were they chosen, and what steps were taken to protect them and to monitor their health while they were in the cleaning up process?

Dr. VELIKHOV. We have a special medical service on the site, and this is a very big service, because some very big amount of service groups are working with the people, with the population. But we have special services for the people who are working in this station with the contamination.

And we have quite strict rules. We have full accounting of radiation, dosage of radiation. We use the dosage-meters, and a full account of how much you have. We have special blot analysis, blot test. We have special measures to clean clothes, a special facility which is available for everybody to clean themselves, and special teams which monitor your health on the site very carefully.

To my knowledge, I do not know of anybody who has had a real health effect from working—but some people have gone to the hospital, yes. I was one who went, but for a different reason.

Senator HATCH. According to Western news reports, they indicated that some of these people were conscripted, were actually forced into cleaning up, and in addition, a series of articles in the Nortal—is that the way you pronounce it—which is the Estonian language daily of the Communist Youth League, apparently were designed to dampen alarm among Estonians about the health of the conscripts who were taken from Estonia.

The stories we get are that there were 200 to 300 Estonian men who were taken and sent to the Chernobyl area where they washed houses and trees and stripped contaminated topsoil, and after being informed that their two-month duty had been extended to six months, actually went on a temporary strike.

Is there any truth to those allegations?

Dr. VELIKHOV. No, I do not have any such information. But I only know the very big amount of people who voluntarily asked to join us in Chernobyl. And I have never seen any men who said anything against it, working together.

I think in Chernobyl, we worked in conditions very similar to conditions in the front; we faced disaster, and we felt our responsibility to stop this, to save the people outside this area. And in such case, the feeling of brotherhood between the people who worked in Chernobyl was extremely big. That is my personal knowledge.

Senator HATCH. Thank you, sir.

The CHAIRMAN. Senator Simon?

Senator COCHRAN. Excuse me, Mr. Chairman. May I ask a question about procedure?

The CHAIRMAN. Yes.

Senator COCHRAN. I was under the impression in earlier hearings that Senators were recognized in the order in which they came to the hearing. Is that the procedure?

The CHAIRMAN. We have tried, with a time constraint, to follow that. We do not have unlimited time this morning. But as the general format of the hearing, what we have tried to do is go from the Chair to the Ranking Minority and then to rotate back and forth. If we have a particular time constraint, it would seem to be to be fairest, as we have with Secretary Bennett—we only had him for 45 minutes—to go to those who have gotten here first.

I want to point out that the Senator from Mississippi was the first person here this morning. If it is agreeable to the other members, I would recognize him after the Senator from Illinois. Otherwise we will have to rotate back and forth.

I will indicate at the start of the hearing if we are going to follow the other procedure, but we want to try and accommodate. And I would mention to my friend from Mississippi if there was a particular time constraint on him, that we will try to accommodate that as well. But if I do not announce at the start of the hearing, we will follow the more traditional way of going back and forth.

Senator Thurmond?

Senator THURMOND. Mr. Chairman, I would be glad to yield to the able Senator from Mississippi, since he was here. However, I think a sound policy is to go by seniority because, for instance, I am on several committees—although I am not very high in seniority on this Committee—but the point is, I am on several committees as the rest of you are. Now, Senator Hatch came in, and although I had been here a good while, I thought it proper that you recognized him, because he had staff members tell him when they thought he would be needed here. I imagine Senator Stafford has done the same thing, and I have done the same thing, that is, tried to be here when I thought my time would come.

But I hope you will follow that system. I think otherwise it might cause trouble.

But I now yield to the distinguished Senator from Mississippi.

The CHAIRMAN. Well, just before you take that privilege and opportunity, I thought we would recognize the Senator from Illinois, and then we will recognize the Senator from Mississippi. What we will basically do is we will rotate back and forth along the seniority—unless there is a very defined period of time, and I will outline the procedure at the start of the hearing. Otherwise we will rotate.

Senator Simon?

Senator SIMON. Thank you, Mr. Chairman.

I might say to Senator Thurmond that Senator Cochran and I are a little less enthusiastic about seniority than you are.

Senator THURMOND. After you have been around here a while, you will change your mind. [Laughter.]

Senator SIMON. First of all, Dr. Velikhov, let me commend you for being here. I think it is, again, a small thing, but these small gestures between our two countries are very important, and I think

your appearance here is one of those small gestures that does help to develop understanding and trust between our two countries.

In that connection, let me also comment your government. Yesterday, Mrs. Ina Miyman—you say "Miyman", I believe, is the Soviet pronunciation—arrived here for cancer treatments; we appreciate that, and I hope her 75 year-old husband will be permitted to join her very shortly, too.

Let me go to the area of international cooperation that you talked about. After the Chernobyl accident, Senator Hart and I wrote a letter to the Secretary of State, urging that there be a special meeting convened, an emergency session of the International Atomic Energy Commission.

Is the International Atomic Energy Commission structured in such a way as to deal effectively with the kinds of problems we face between nations? Are there ways that it should be strengthened?

Dr. VELIKHOV. My feeling is—I have a quite positive view of the international agency, not only as the agency that is working on the guarantee of nonproliferation and of other issues, but I experienced work in technical matters. We designed a fusion reactor for eight years, and it was a very good experience internationally. I think the international agency, with enough support, is a very good place to be a center for such activity. But in any case, it is very important to make parallel, bilateral agreements. I think we already are involved in such cooperation, like agreements on fusion, and at the same time, to have much more cooperation between different organizations directly.

I think altogether, the international agreements, the role of energy and bilateral cooperation solve these problems, because there are an immense amount of problems which are necessary to solve.

Senator SIMON. When you say the International Atomic Energy Commission, "with enough support" is the phrase that you used—I guess the follow-up question is, "Are we—the Soviets and the United States—giving that Commission enough support?" Does it need to be strengthened?"

Dr. VELIKHOV. I am a little worried to answer for Mr. Bleaks [phonetic], but I think maybe it is better to say it is necessary to give the support which is necessary. And I am not the right person to answer you, because I think it is possible, but I do not know exactly what is happening today and what is the plan for your government. I think our government plans to give all necessary support.

Senator SIMON. Then let me follow another point that you made and that is, you mentioned work on fusion. Is it possible or desirable that the Soviet Union and the United States work together more cooperatively in research on fusion—and frankly, not simply on fusion. I met in Moscow a couple of years ago with the President of the Academy of Sciences, and we talked about doing joint research on desalination of water and finding an inexpensive process for doing that.

Can we structure things so that there is greater work between our two countries in these areas?

Dr. VELIKHOV. Already with the United States, we have government agreement from 1973, and I participated in establishing this cooperation on fusion, and this cooperation was very effective. As an example, you in the United States use our technology of Tocomoc [phonetic] very effectively; it is your main line. We share theoretical results. Our scientists are working in installations in this country.

Sometimes, it is more difficult to go to the big projects. And as an example, I speak of fusion, but maybe it is possible to use other examples. Fusion is a very good candidate for this for three reasons. One reason, it is important for energy development. The second reason, it has nothing to do with military; in such a case, it is open field in which the U.S.S.R. and the United States have the same level of technology. We have full capacity to build fusion reactors ourselves, and you have, and if we share our knowledge and our resources, we go much faster. And third, today the fusion is not in the commercial state, and in such case, there are no problems of commercial or private rights, no problems of commercial secrecy, and it is a proper time to cooperate. After this, the industry has its rights to develop fusion to a commercial state, and in such state, the cooperation between two countries in my understanding is much more difficult. And today, it is the proper time to cooperate very deeply in fusion.

If we find other examples of projects, I think yes—why not? We are very happy to cooperate.

Senator SIMON. And when you say today is the "proper time" to cooperate on fusion, are we moving in that direction adequately?

Dr. VELIKHOV. Frankly speaking, my feeling is no, because we propose to make a decision to build a fusion reactor together. Today your answer is yes and no—yes, to design, but no commitment. But without commitment, such kind of high-cost, long-term project is very difficult to go really to the results.

Senator SIMON. May I ask you to, after this session and when you return and upon reflection, to send me a letter outlining what you think we should be doing, and I will share it with my colleagues.

Dr. VELIKHOV. I am very happy to. Thank you. I will send it.

Senator SIMON. Thank you.

Then, one final question—and Mr. Chairman, you will be interested in this. You mentioned it is more dangerous on radiation exposure if you smoke. And I ask this question——

Dr. VELIKHOV. No, no, no, not radiation—just the chance to have cancer.

Senator SIMON. Oh, right. But on behalf of the Chairman, I am asking this question: Does that apply to cigars, too? [Laughter.]

The CHAIRMAN. I try and burn Mr. Castro's crops any time I get a chance. [Laughter.]

Senator SIMON. I thank you, Dr. Velikhov.

The CHAIRMAN. I will recognize Senator Stafford, and if he wants to yield, will recognize Senator Cochran.

Senator STAFFORD. I will be glad to yield to the Senator from Mississippi.

The CHAIRMAN. The Senator from Mississippi.

Senator COCHRAN. Thank you, Mr. Chairman.

Mr. Velikhov, I think it is clear to everybody from the Chernobyl experience that the consequences of a nuclear accident can extend beyond the boundaries of the nation in which the nuclear reactor is located.

Because of that, there is an obvious concern in the international community about the safety of nuclear reactors that are in operation today. I am told that there are about 370 nuclear reactors in operation, generating electricity around the world today, and that moreover, about 157 are presently under construction, new ones. Only about 26 of those are in the United States. So around the world, a large commitment is being made to the construction and operation of nuclear power plants.

Given those facts, is it your opinion that there should be an international regime of safety standards that would apply worldwide and some agency with the responsibility to conduct inspections to make sure that those safety measures are being adhered to throughout the world?

Dr. VELIKHOV. Yes, I think so. I think it is necessary to develop special standards by the international agency and to give this agency the possibility to enforce these standards, by agreement, of course.

Senator COCHRAN. I think it is interesting to note that both your country and our country have been leaders in the effort to develop an international regime of nuclear nonproliferation standards and safeguards that are in place that try to help prevent the diversion of nuclear fuels for the purpose of constructing nuclear weapons. And we have a long history of cooperation in that regard. I wonder whether or not you foresee that same kind of cooperation developing in the area of international nuclear safety?

Dr. VELIKHOV. I hope so. I think it is very important to develop such type of understanding.

Senator COCHRAN. Would you be willing to recommend as a scientist in the Soviet Union to your government that it agree to onsite inspections of its nuclear power generating plants to see that safety standards are being adhered to there?

Dr. VELIKHOV. I think it is already agreed in the discussion in Vienna and all these proposals of an internationally safe regime of operation of nuclear stations.

Senator COCHRAN. Would this extend to an agreement that the International Atomic Energy Agency could be the agency to select the civilian nuclear power plants that are to be inspected; or would the selection be by the Soviet Union?

Dr. VELIKHOV. Oh—really, I do not know now the details of this agreement.

Senator COCHRAN. But it would be your recommendation that such permission be granted for onsite inspections?

Dr. VELIKHOV. Yes.

Senator COCHRAN. Have you ever been to the facilities in Cuba where the Soviet Union is assisting Cuba in the construction of nuclear power plants at Cienfuegos?

Dr. VELIKHOV. No, I have not. I am not specialist in the building of fusion reactors—if this is a fusion reactor in Cuba.

Senator COCHRAN. There are two power plants under construction there, I am advised, and I was wondering whether or not you

were familiar with the design of those plants, whether they were of the Chernobyl type design or not.

Dr. VELIKHOV. For this very important hearing, I do not wish to make some sort of vague answer. But to my knowledge, this reactor is pressurized water design—I think—I think—because we never export the graphite reactor outside.

Senator COCHRAN. Because of the fact that the damages from a nuclear power plant accident can and will be felt in neighboring countries, such as we learned from the Chernobyl accident, to what extent has the Soviet Union tried to assess the damage that was done in the Chernobyl accident in other countries?

Dr. VELIKHOV. I think this is a question which has already been discussed in Vienna, and this discussion is not finished because it is necessary to establish—we gave some proposals, and it is necessary to establish a regime by law. And to my knowledge today, there is no such regime, because it is a two-sided question. On one side, it is necessary to establish the real damage; and on the other side, to establish the imaginary damage, or damage made by misinformation or other things.

Senator COCHRAN. Were you a part of the delegation attending the meeting in Vienna in August of 1986?

Dr. VELIKHOV. No, no, no.

Senator COCHRAN. But you led the team at Chernobyl in the containment effort?

Dr. VELIKHOV. No, I did not lead. The situation was this. First of all, we have a permanent government commission which is headed by Shcherbina, and Legasov was a member of this commission. But because this commission had no possibility to work all the time in Chernobyl, for health reasons—for many reasons—we have the so-called "shifts" commission. And I work with three commissions headed, consequently, by three different Vice Chairmen of our Council of Ministers, and I work with this group. In such case, I was not involved in the preparation of the presentation in Vienna and not involved in the discussion in Vienna.

Senator COCHRAN. It was my pleasure to be at Vienna at the meeting in August of 1986 as an observer; I was not a part of the official U.S. delegation. But nonetheless my recollection is that an agreement was reached that while the international community shared a responsibility to try to find out answers, such as how do you mitigate the effects of a nuclear power plant accident and how, more importantly, do you prevent one from happening, it was agreed, as I recall, that the primary responsibility for preventing an accident lies with the nation in which the nuclear plant is located.

I presume you would agree with that?

Dr. VELIKHOV. Yes, I would.

Senator COCHRAN. And so the primary responsibility for damages that would occur as a result of an accident would likewise be the responsibility of that nation where the plant was located. Don't you agree with that?

Dr. VELIKHOV. Yes, I think it is natural.

Senator COCHRAN. And so wouldn't it be appropriate for the Soviet Union to try to assess what damage did occur as a result of Chernobyl; try to determine who has been harmed, who the victims

are, the extent to which they have been harmed, and then respond with compensatory benefits or payments to compensate them for those damages?

Dr. VELIKHOV. In such case, I have not now all the details of this, because in my feeling, first of all it is necessary to have some kind of agreement and framework for some legal ground to make such assessment.

Senator COCHRAN. Mr. Chairman, I really think it is very clear as a result of Chernobyl and the testimony that we have heard, that there is a definite need for us to support an international safety regime with clearly-defined rules and responsibilities, if that can be worked out among the nations of the international community. I think we ought to take a position of leadership in that effort.

I know there are others here, and there are other questions. This is a very difficult and complex subject area. But I would like, Mr. Chairman, with your permission at this point to include in the record a copy of an article I wrote in the Washington Post immediately following the Chernobyl incident; and a copy of an article that was published by the Christian Science Monitor in October of 1986 on the subject of the international safety regime; and an article in the Memphis Commercial Appeal, describing the events of the Vienna meeting in August of 1986.

Thank you.

The CHAIRMAN. Thank you very much. We will have those so included.

[Information supplied for the record follows:]

International watchdog urged for N-plants

By James W. Brosnan

WASHINGTON — To lessen the chance of another Chernobyl disaster, countries must agree to nuclear plant safety standards enforced by an international agency, says Sen. Thad Cochran (R-Miss.).

Cochran was the only member of Congress at a recent international meeting of more than 500 scientists where the Soviet Union reported on the causes of its nuclear plant accident, in which 31 people died and thousands more were exposed to potential cancer-causing radiation.

Cochran said he was impressed by the Soviet Union's new willingness to improve its plants but was equally convinced that another nuclear accident could occur unless the Chernobyl lesson is learned in other countries, especially smaller nations just starting nuclear plants.

"I think it would be less likely to happen if we could get into place a set of minimum safety standards and have an agency identified with the power to inspect and to enforce compliance with those standards," said Cochran, who heads a Senate subcommittee on nuclear proliferation issues.

The meeting of the International Atomic Energy Agency (IAEA) in Vienna in late August already is spawning two proposed treaties, one to require notice to a country's neighbors in the event of a nuclear plant accident and the second governing emergency response to an accident. Drafts are expected to be approved later this month.

Cochran said, however, that treaties also are needed to allow IAEA to enforce standards in nuclear plant construction and operation.

The agency, which reports to the United Nations General Assembly, now conducts safety inspections if invited by a country, which doesn't have to follow the advice. Only five were conducted in 1985.

COCHRAN WANTS IAEA to regulate plant construction, employee training and operations standards. He said he is hopeful because the Soviets would welcome plant inspections by IAEA and to consider notification and emergency response conventions in the wake of the April 26 explosion at Chernobyl.

Other countries are still reluctant, but, Cochran said, "I think they've learned that an accident can occur across the boundary and still have considerable impact (from fallout)."

The scientists in Vienna found the Soviets do not have the same nuclear expertise as Western nations. Cochran said he's also concerned about "other countries that are less well-developed, where the sophistication level is still lower than that."

There are 374 nuclear plants generating electricity in the world, with 101 licensed in the United States. Of the 157 under construction, only 26 are in the United States.

While plant standards are stricter in the United States than most countries, the United States also must abide by any international treaty, said Cochran.

"From a political standpoint, the American people are going to have to be satisfied that we are able to protect the health and safety of citizens and the environment or they're going to insist that nuclear power facilities be phased out," said Cochran.

Where Congress can help is in pushing for a world standard and appropriations for IAEA, which now lacks the budget for an expanded safety role, said Cochran.

IAEA employs about 1,800 people, and has a budget of about $125 million. The United States contributes about one-fourth the cost. That figure compares to a budget of more than $4.30 million and nearly 3,500 employees for the Nuclear Regulatory Commission, which governs U.S. plants.

James W. Brosnan is a reporter in The Commercial Appeal's Washington bureau.

Bill Sanders, The Milwaukee Journal

Commercial Appeal

THE CHRISTIAN SCIENCE MONITOR

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Nuclear safety: grounds for optimism

By Thad Cochran

ALTHOUGH overshadowed by reports of superpower disagreement, conferences reopened last week in Vienna at the International Atomic Energy Agency which justify optimism not only for greater nuclear plant safety worldwide but also for significant improvement in relations between the United States and the Soviet Union. In the current tension caused by conflicting espionage accusations in the two countries, the superpowers should not allow themselves to be diverted from this hopeful course.

In August, at a five-day symposium on the Chernobyl disaster attended by experts from 62 countries and 21 national and international organizations, the Soviet Union was far more forthcoming than many people had expected in describing the accident and its radiation effects on the population. While not all questions were answered during the conference, the Soviets promised to share additional information as soon as possible.

About a week before this technical conference, representatives of 56 nations, including the US and the Soviet Union, completed two draft conventions, one on information exchange and early warning of nuclear accidents and another on coordinated emergency response to such incidents. Consensus on these agreements was reached in the remarkably short period of four weeks.

Delegates from the energy agency's member states began meetings in Vienna last week to receive the draft conventions and to discuss strengthened international cooperation in nuclear safety. Next month another group of experts will return to consider additional measures for improvement.

Thoughtful people everywhere look to these conferences to produce a unified course of action to lessen the likelihood of accidents at nuclear plants. The August meetings dealt with mitigation — what should be done after a nuclear accident. The nuclear energy agency must now deal with the issue of prevention — the improvement of nuclear safety standards worldwide.

Standards already exist; the issue is whether countries will promise to follow them.

The agency has established safety guidelines covering such areas as plant siting, design, and operation. It has offered to conduct on-site reactor safety reviews by teams of it staff and outside experts. There is an agency reporting system through which countries may exchange information on plant malfunctions.

However, nations have failed to reach an international agreement binding them to IAEA standards. Safety teams are sent only when requested.

Thus far, however, nations have failed to reach an international agreement binding them to follow the agency's standards. Safety teams are sent only when requested. Exchange of information and use of the reporting system are purely voluntary.

A stronger system of international safety standards, together with a verification system to ensure compliance, would raise difficult technical and political issues. The cost will be high, and governments must be convinced the expense is justified. Moreover, growth in agency safety inspections must not detract from its vital nonproliferation safeguards, which verify that fuel at power plants is not diverted to make weapons.

Delegates at the conferences now under way should go at these issues and determine how rapidly the agency can expand its capacity and authority to deal with nuclear safety. The superpowers must take the lead in this process.

Recent events in Vienna, Stockholm, and elsewhere justify optimism that they will assert such leadership. The US and the Soviet Union have been major supporters of the energy agency, and their joint backing has solidified in the aftermath of Chernobyl. American and Soviet leaders have called for a greater international effort to improve safety in national nuclear programs.

Both nations have agreed to on-site inspections of the dismantling of facilities that produce chemical weapons. During recent negotiations on European confidence-building measures, the parties accepted the principle of limited on-site inspections of internal military activities.

A recent US-Soviet nuclear safety research protocol will permit reciprocal on-site visits to selected nuclear installations in each country next year.

The Chernobyl accident has internationalised the peaceful atom. It has demonstrated that "a nuclear accident anywhere is a nuclear accident everywhere." By submitting a detailed report on the incident to the world community, and by agreeing to accept the two conventions on the mitigation of future accidents, the Soviet Union has exhibited unusual candor and a willingness to cooperate in the improvement of international nuclear safety.

Despite deep superpower disagreement on other issues, let us hope that this cooperative spirit between the US and the Soviet Union in nuclear safety continues to grow, so that the international effort to deal with a painful accident results in genuine progress toward greater peace and security for all nations.

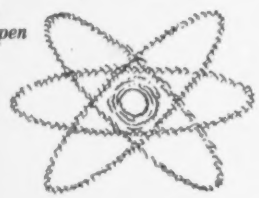
Thad Cochran, a Republican senator from Mississippi, is chairman of the Governmental Affairs Subcommittee on Energy, Nuclear Proliferation, and Government Processes.

THE WASHINGTON POST . THURSDAY, MAY 1, 1986 A23

Thad Cochran

The Chernobyl Example

All civilian nuclear plants, says the Mississippi Republican, should be open to international inspection.



The accident at the Chernobyl nuclear power plant in the Soviet Union has heightened worldwide interest in the safety of more than 340 commercial nuclear power plants—more than 240 outside the United States—which produce more than 13 percent of the world's electricity. These nuclear facilities involve large quantities of radioactive material that must be carefully controlled, a task that is complicated by design and operational differences among the facilities.

The focus for years has been the danger that some of this material might be diverted from peaceful generation of electricity to military production of bombs. In fact, this "proliferation" has long been regarded by many as the major security problem confronting the world, since growth in the number of nations possessing thermonuclear arms might increase the danger of nuclear conflict.

Most nations that have decided to develop civilian nuclear power have gradually come to accept the desirability of controls to inhibit proliferation. These restraints are contained in a collection of treaties, agreements and voluntary commitments to prevent the spread of nuclear weapons. A system or "regime" has grown up in which record-keeping, audits, inspections and technical controls ensure that nuclear materials and equipment intended for peaceful use are not diverted to military purposes by countries not already possessing nuclear weapons.

These "safeguards" have become the heart of the international nonproliferation regime. They have evolved principally through the work of the International Atomic Energy Agency, created in 1957 to control as well as to promote nuclear power. They mark the first instance in history of sovereign nations' inviting an impartial international organization to audit their accounts and conduct inspections on their own territory. Some 95 percent of all nuclear installations in countries not possessing nuclear weapons are now under safeguards.

The United States and the Soviet Union have an established record of cooperation in this nonproliferation effort. Both countries were leaders in negotiating the Non-Proliferation Treaty; both ratified the Convention on the Physical Protection of Nuclear Material; both are major supporters of the IAEA.

What does this have to do with the Chernobyl tragedy?

Just this: the IAEA also has extensive capabilities in the area of nuclear safety that, if they had been used by Soviet authorities, might have averted the catastrophe. IAEA nuclear safety standards cover every aspect of the design, siting, construction and operation of the most common types of power reactors.

The increasing number of operating nuclear plants makes the prevention of accidents at power stations a widespread concern in the international community. Previously, our concern has been to protect nuclear facilities and materials from diversion for the purpose of making explosives. The IAEA has been effective in strengthening safeguards to give the world this protection.

The improving safeguards system has broad significance as a confidence-building mechanism whereby nations can increasingly rely upon international verification. In this regard, we should take heart from the expressed willingness of all countries already having nuclear weapons—the United States, the United Kingdom, France, the Soviet Union and China—to accept safeguards on selected civilian nuclear facilities.

Consideration should now be given to an increase in IAEA's authority to enable the agency to inspect *all* civilian nuclear facilities for safety, giving an additional meaning to safeguards. We should at once begin an effort, in cooperation with other nations, to persuade the Soviet Union to agree to allow IAEA to choose for inspection any of its civilian nuclear power plants, just as the United States and the United Kingdom already do.

The framework for negotiation and agreement already exists in the nonproliferation regime. As in the case of nonproliferation, international nuclear safety requires constant vigilance. Ensuring a safe nuclear future demands plain talk and deserves our most determined effort.

The writer, a Republican senator from Mississippi, is chairman of the Governmental Affairs subcommittee on energy, nuclear proliferation and government processes.

The CHAIRMAN. I just want to mention, just as the Senator is leaving—I would reserve this—I think that this is a matter of real concern, Academician Velikhov. I think as far as I am concerned, it goes beyond the questions of radiation. We find that we are faced with pollution of our coastal areas. We have oil spills that come up on our beaches and contaminate important areas of fisheries and other areas; and we have acid rain in terms of part of our own country which has polluted. And we have Bhopal, in terms of commercial pollution.

So clearly, I think this is an area of very deep concern and obviously, this area of radiation and radiation activity has enormous life and death kinds of implications in some instances. But I think you have gathered from the membership a deep interest in it.

Senator Stafford?

Senator STAFFORD. Thank you, Mr. Chairman.

Dr. Velikhov, I was not able to be here at your opening statement to this Committee, so I apologize if one or two of my questions, which will be brief, are repetitious.

How many nuclear power plants are operating now in the Soviet Union?

Dr. VELIKHOV. I am not very good in numbers. I will try to find it exactly.

Senator STAFFORD. If you can give us just an approximate idea, that would be satisfactory.

Dr. VELIKHOV. I think, near 30; but I will give you exact numbers—if you wish, I can give them to you after the session. I will present the exact numbers of type of reactors and how many we operate.

Senator STAFFORD. Oh, you will give it to us after—all right.

Dr. VELIKHOV. I have all the materials with me, but——

The CHAIRMAN. You may submit that for the record as part of your testimony.

Dr. VELIKHOV. All right.

Senator STAFFORD. Could you give us just some very approximate idea of how many there are? Are there 20 or 30 or 100?

Dr. VELIKHOV. I think, 30.

Senator STAFFORD. Thirty. Could you indicate how many of whatever the number is—and we will accept what you tell us, of course—but how many of that number may be of the Chernobyl type?

The CHAIRMAN. In terms of the design, I imagine he is referring to.

Senator STAFFORD. Yes, yes.

Dr. VELIKHOV. Yes, yes. It is one-third, I think.

Senator STAFFORD. One-third?

Dr. VELIKHOV. But I will give you the exact numbers and names of the stations and names of the units, because the problem today is to calculate how many units are shut down, how many are in operation. I have all the material with me, and I will give that to you.

Senator STAFFORD. As a very approximate figure, how big a percent of the electrical power generation in the Soviet Union comes from nuclear power plants?

Dr. VELIKHOV. I think today we have 10 percent.

Senator STAFFORD. Ten percent. Then, if those plants were shut down, those that are designed similarly to the Chernobyl plant, that would roughly shut out 3 or 4 percent of the available power in the country; would that be accurate?

Dr. VELIKHOV. Only one percent, I think.

Senator STAFFORD. How much?

Dr. VELIKHOV. I think, one.

Senator STAFFORD. Well, if the nuclear plants generate 10 percent of the total power, and one-third of them are——

Dr. VELIKHOV. We would lose 2 gigawatts, and that is less than one percent.

Senator STAFFORD. All right.

Dr. VELIKHOV. You are asking all Chernobyl stations, or only Units 3 and 4?

Senator STAFFORD. It appeared to me that if——

Dr. VELIKHOV. We are already operating Units 1 and 2.

Senator STAFFORD. I was trying to understand the impact of shutting down the Chernobyl-type power plants, were they shut down, on the total power generated by nuclear plants in the country, and on the total power generated by any means in the country. And it would appear to me it was about 3 percent—but I was never much good at mathematics.

Thank you, Mr. Chairman.

Senator SIMON. If my colleague would yield——

Senator STAFFORD. I would be glad to yield.

Dr. VELIKHOV. But the real problem is not only the global problem of how many percent we have, but a local problem, too. We have general systems, but we have local systems, too.

Senator SIMON. I think Senator Stafford's question is if, on the graphite-type nuclear reactors that you have, if you were to close down, if you were to stop all the graphite-type nuclear energy stations, that would be what percent of the energy in the Soviet Union?

[Pause.]

Dr. VELIKHOV. I could give a rough estimation, but it would be much better if I give you—a few percent, yes—but I will give you an exact number. I have the materials, and it is just simple arithmetic, but I do not keep in my head all these numbers.

Senator SIMON. That is all right.

Before I yield the floor, Mr. Chairman, in view of Senator Simon's assistance here, I will say that yesterday at a meeting at which I was the luncheon speaker and I think you followed as a panelist, I told the senior representatives of the Department of Education who were present that if they could explain their higher education budget to you satisfactorily, they could probably explain it to me. [Laughter.]

Senator STAFFORD. I yield the floor.

The CHAIRMAN. Senator Thurmond?

Senator THURMOND. Dr. Velikhov, I want to join in welcoming you here to our country. I was in the Soviet Union last year, and in an area at one time which is not too far, I think, from this Chernobyl incident; I was also in Moscow after that. We had the pleasure of meeting with Mr. Gorbachev for three and one-half hours, seven other Senators and myself. And I think you have a beautiful coun-

try and a great country, and I hope as time goes by that it can be opened up more and adopt a system in which people will have more freedom.

I want to ask you how many people were killed in this incident at Chernobyl?

Dr. VELIKHOV. Thirty-one died—not "killed", but "died"—because only one man was killed by debris; but other people died from radiation sickness.

Senator THURMOND. Thirty-one. How many others were injured?

I realize I have a Southern accent, and you may not be able to understand me. [Laughter.]

Dr. VELIKHOV. Those with radiation sickness are 237—but most of the people are already out of the hospital and working.

Senator THURMOND. Is there a prognostication that they will suffer cancer or some other serious disease as a result of the Chernobyl incident?

Dr. VELIKHOV. Of course, there is some increase of probability, but this increase is quite small. And I am working in an institute where many people have exposures in their lifetimes similar to this dose. Of course, there is some increase of probability of cancer, but not very dramatic, and it depends, of course, on the dose and the physical condition. And I am not a physician to tell you.

But from my level of dose, the probability is extremely small. But the people who have radiation sickness, they have doses from 100 to 1,000 rem, but mostly the people with the high dose have already died. The people in the low range, I do not know exactly how big is the increase of probability.

But in my case of 30 or 40 rem, this increment is extremely small.

Senator THURMOND. As I understand from your testimony, your government has taken steps to prevent a recurrence of an incident of this type in the future.

Dr. VELIKHOV. Of course, we have taken many steps to be sure that this never happens again.

Senator THURMOND. In other words, you think you can prevent such an incident happening again?

Dr. VELIKHOV. Yes, I hope, yes.

Senator THURMOND. What assessment has been made as to the damage to the water system in your nation as a result of this incident?

Dr. VELIKHOV. After all the measures which we have already taken, which I have mentioned here—this concrete wall around the power station in soil, 50 meters deep; the tens of kilometers for dumps; drilling of drainage holes and stopping the rains altogether—these give us the assurance that we have no problem with the water supply today.

After the first plume of contamination, after the first days, we have never had any water supply problem.

Senator THURMOND. You have not received any evidence of any damage to your water system as a result of this incident?

Dr. VELIKHOV. No.

Senator THURMOND. Mr. Chairman, I have a lot of other questions I could ask, but in view of the time limit, I will stop here.

Thank you very much.

The CHAIRMAN. Thank you very much.

Dr. Velikhov, if I could, having gone through this hearing this morning, which has been enormously helpful to us, as I gather, you were in charge of the scientific assessment team at Chernobyl for the Soviet government.

Dr. VELIKHOV. Not assessment. I am sorry. I am in charge of the scientific team which supports the work; but I am not working on assessment. I work on repair, a repair team.

The CHAIRMAN. I see. If I could, let me just move into one area that is related in the fact that it deals with potentially nuclear power, and that I know that you are very much involved in. And I will ask the understanding of our Committee members who have necessarily had to absent themselves.

I know you were with General Secretary Gorbachev at the Iceland Summit; am I correct.

Dr. VELIKHOV. Yes.

The CHAIRMAN. And I know the American people will be interested in knowing exactly what the Soviet position is now with respect to research and development of Star Wars technology. Could you share that with us?

Dr. VELIKHOV. Yes. I think in Reykjavik, the Soviet government took a big step in the direction of the American position. And I think the main point is that we agreed to the possibility to have so-called research and testing in laboratory conditions. And laboratories do not necessarily mean building or closed buildings; it is the possibility to test in the field, but not in the environment which gives the real test of weapons.

I think there are two boundaries. One boundary is the boundary which is through what you mean by elements and components of the system. The elements and components, one example is in the ABM Treaty, we have the component of radar, which is measured by radar, which as related to the ABM problem, is measured by space and power, production of space and power. And in such case, it is possible to make a boundary between component elements and just some lesser example which is not powerful enough to put in the category of elements or components.

This is one boundary, and the other boundary is environment—space environment or environment on the earth, which is completely different.

In such case, I think we have taken very good steps to the better understanding of the American position to continue its research, and it opens a real chance to have real agreement.

The CHAIRMAN. As I understand what you are saying, you are talking about the issue of Star Wars in a functional way rather than a physical way. I think many, both members of Congress and the American public, think that what we have been talking about in trying to find some path toward resolving the differences in Star Wars—I have my own views about the weapon system, but let us just take now the question of the negotiation—basically, what we were talking about was what was going to happen physically, what was permitted physically in space, whether particular components were able to be tested in space, whether they would violate the ABM treaty or whether they would not.

I think for the most part, there was as sense that what we are talking about is the physical materials, as I say, the various components in space. And what I hear you talking about now is a different concept, to look at it kind of functionally in terms of the radar—you mentioned there are different types of radar with different functions, there are different lasers with different kinds of performances. And what you are talking about is to try and seē if there can be at least some meeting of the minds in talking about the functional aspects of the research program rather than the physical boundaries of the laboratory. Is that correct?

Dr. VELIKHOV. Yes.

The CHAIRMAN. OK. If there is any single lesson to be drawn from the Chernobyl experience it is this—that if such an accident is unthinkable, if it is not possible to conceive of this kind of human error actually occurring, the consequences are similarly unthinkable. We know from long years of history that to err is human; but when humans are involved with nuclear power and nuclear weapons, to err may mean the end of the world.

And as we go forward into the fifth decade of the atomic age, we ought to at least learn from this experience that technology may not be perfect, but neither is humankind; and to the extent that we trust our fate to ever more complex systems, to ever more dangerous technology, we increase the risk to all humankind.

We want to thank you very much, Academician Velikhov, for appearing here. We will ask you if you might step down, and we will now hear from Dr. Gale.

Dr. VELIKHOV. Thank you.

The CHAIRMAN. Dr. Gale, as I mentioned earlier, has taken an overnight plane from the West Coast and has joined us here this morning.

I know you have a number of slides. We will ask you to proceed in whichever way you would so desire.

STATEMENT OF DR. ROBERT T. GALE, DIRECTOR, BONE MARROW TRANSPLANT DIVISION, UNIVERSITY OF CALIFORNIA AT LOS ANGELES, AND CHAIRMAN, INTERNATIONAL BONE MARROW TRANSPLANT REGISTRY

Dr. GALE. Thank you. I want to thank you for the opportunity to appear before this Senate Committee. I think the presence of both Professor Velikhov and myself indicates the fact that the international scientific community considers this such an important issue that it transcends the usual political boundaries which divide our countries.

I would try to be brief. Professor Velikhov has reviewed the physical aspects of the accident, and I was going to try to briefly review some of the biomedical consequences.

I do not know if we can have this projected any better than it is. This first slide, if you could see it, is just a projection of the world and it would show you the fact that there are nuclear power stations distributed throughout the world.

The point really is that we live in a nuclear age. We are going to have to come to grips with the use of nuclear energy in this next hundred years.

I will now try to describe what is on this next slide. We in the United States derive about 16 percent of our electricity from nuclear sources. You will see that the Soviet Union gets about 11 percent, and will plan to get about 50 percent, according to Dr. Velikhov's statement, by the year 2000.

Again, the point is that we live in a nuclear age. We in the United States have the great privilege to decide if we wish to pursue nuclear energy or not, but the rest of the world is going to pursue nuclear energy and, for example, the Japanese will have over 125 reactors on line by the year 2030.

Now, the events at Chernobyl show that nuclear energy is an international force. It does not make that much difference who owns the reactor when one of these things gets into trouble.

So my point really is that we have to come to grips with the use and living with nuclear energy for the next 50 or 100 years.

If I could have the next slide, this just shows you for orientation the site of the Soviet reactor at Chernobyl, which is located next to the city of Pripyat, just about 130 kilometers north of the city of Kiev, the third largest city in the Soviet Union.

Could we have the next one?

This is what the Chernobyl nuclear power station looked like before the accident. The building with the smokestack houses the third and fourth units, and the next slide will show you the unit. This is the unit after the accident. These are the types of helicopters that the Soviets brought in to deal with the accident.

I think you can just see the destroyed reactor unit, and as Dr. Velikhov has pointed out, the physical destruction is not proportional to the considerable medical implications that I am going to discuss briefly.

Next slide, please.

Now, when the reactor exploded, a radioactive plume was ejected into the atmosphere to a height of about five kilometers, and on the left you see the plume being driven by the winds northwesterly over the various portions of the Soviet Union and up into Scandinavia.

These are computer plots of the projected path of the radioactive plume showing it extending over northern Sweden, where you know that reindeer have become radioactive and had to be destroyed. And then the final panel shows you the drift of the radioactive cloud downward over western and eastern Europe.

Next slide. I am covering these points quickly because I want to dwell on the biomedical consequences.

These next two slides make the point that these are, again, international events. This was the I-131, Iodine-131, surface-air concentrations just after the accident, three days later. You are looking at the world from the North Pole projection, and the next slide will show you the distribution on May 12th.

My point really is that it comes very, very close to various portions of North America and the United States. So, again, these are international problems; they are not the problem just of the Soviet Union.

Can I have the next slide?

Now, briefly, these are the interventions that we consider in response to a nuclear emergency: assessment of the situation, con-

tainment, trying to reduce exposure of affected individuals, trying to estimate the dose, and then trying to intervene as medically indicated.

Assessment has already been covered by Professor Velikhov. Let me just say a brief word about containment on the next slide. This is just a schema of the Chernobyl nuclear power station, with the reactor core shown in yellow and the crane above it, and in the blue you see areas that are containment areas.

And I would just ask you to compare this structure to the next slide, which is a view of the TMI, or the typical American type nuclear reactor, where you see the entire reactor core is housed within a containment building. So these are rather different in concept.

Now, we do have some reactors similar to Chernobyl; the Soviets have some reactors similar to ours. But by and large, ours are of this type and the Soviets' are of the previous type.

Next slide.

Now, the consequence of these different types of containment is shown on this slide. The difference in the release of radiation from the two reactors, from TMI and from Chernobyl, was a difference of a factor of about three.

But you can see that the average exposure to a person who lived within ten miles of TMI was eight millirems and it was 5,000 times higher in the group that lived in that radius around Chernobyl, and the reason for that 5,000-fold difference is the difference in containment.

Next slide.

And it unfortunately demonstrates itself in the medical consequences. As Dr. Velikhov has said, about 200 people were injured and about 31 died as a consequence of Chernobyl—those are the red bars—whereas there are no direct injuries or deaths as a consequence of TMI.

Next slide.

Now, let me talk about reduction of exposure, since this is an important problem which affects us as Americans.

Next slide.

The Soviets ultimately had to evacuate an area of 30 kilometers around the nuclear power station, an area of almost 3,000 square kilometers.

Next slide.

And this is the city of Pripyat, which is now deserted and, as far as we know, will remain deserted for some long period of time. This is not a small town, but rather a large, high-rise city.

Next slide.

And the reason one needs to evacuate such areas is shown on this slide. This woman was a cook in the nuclear power station. She did not know there was an accident and she wandered across a field of radioactive grass. Those burns you see on her legs come from exposure to radioactive blades of grass. The burns indicate the importance of getting people out of these areas as promptly as possible.

Next slide.

Now, it is important to estimate the dose, and I just want to show you on the next slide an example of Soviet-American coopera-

tion. We and the Soviets devised a computer program which allowed us to predict the dose of radiation that individuals received, and then we could measure that against what variables we found in the patients.

And you see the dotted line represents the prediction of the curve of dose, and the solid line the actual dose, and so that even under these extremely difficult situations, by working together we could figure out what dose of radiation people had received.

Next slide.

Finally, let me talk about medical interventions.

Next slide.

These are just some pictures of what I would describe as the very brave firefighters who rushed into the power station in an attempt to save the other units from being involved in this accident.

And you see these little red marks on this firefighter's chest which are areas where radioactive particles have landed. This is a very mild example.

Next slide.

You can see the back of one of these firefighters who has lost his hair and has this diffuse burn over all of his skin. Again, I think it is important to emphasize the valiant effort that these fellows made.

Next slide.

Now, we are particularly concerned about——

The CHAIRMAN. What is their prognosis in terms of life?

Dr. GALE. Well, of the 500 people that were hospitalized, 31 died; above five are still in the hospital. So about 95 percent of the hospitalized people are now home, so I think we have gotten off relatively fortunately.

The CHAIRMAN. But those two individuals?

Dr. GALE. The first fellow survived, the second fellow did not. He died of a complication which involved the destruction of the bone marrow. I realize this is not a course in medicine, but this is what your bone marrow ought to look like and the next slide shows you the bone marrow of one of these fireman. You see that the cells have been destroyed by radiation.

Next slide.

Now, what do we do about these kinds of problems?

Next slide. Again, I can only review these very briefly.

These say that the Soviets screened about 2,000 people at the site by counting radiation over the thyroid gland. I have mentioned that 500 were hospitalized, and they got various doses of radiation. We consider all of those doses to be rather serious.

Next.

The major medical activities took place in Hospital 6, which is in Moscow and is just shown here to give you an idea of what this looks like.

Next slide.

This may very likely be an American technical failure. You have heard all morning about Soviet technical failures. We may have reached one of our own.

Well, let me just say that, because these people are at great risk of an infection, we were able to place some of them in these sterile environments to keep them from getting infections, and this is one

of the firemen inside such a sterile environment, or sterile bubble, they are sometimes called.

Next slide.

We treated many of these individuals with some specialized antibiotics, some of which were brought from the United States. This young man has lost his hair. You can see that he has a central line into his great veins, this patch on his chest, and he is being treated with an anti-viral drug from the United States.

Next slide.

The CHAIRMAN. What happened to him? Do you know?

Dr. GALE. He survived, I am happy to say.

And here you see a unique situation. This is a room in a Soviet hospital filled with a bunch of American machines which were flown in with the help of Dr. Hammer from American companies, and those are some of the victims who are having some blood cells removed.

Next slide.

In the very extreme, we had to do bone marrow transplants in some 13 people to try to save their lives, and I will not go into the details. Suffice it to say that this is an extreme measure which we would reserve only for a very, very small proportion of the affected individuals and in which we expect to have a definite but low chance of success. We can save some lives, but not all lives.

Next slide.

And this just, again, is a nice example of international cooperation. This is a Soviet-American surgical team performing these bone marrow transplants.

Next slide.

And this is one of the survivors, one of the firemen who received one of these bone marrow transplants and is now in Moscow, and I and Dr. Baronov, who is shown on the right, see him quite frequently. I just put this up to show you that if things go well, we can rescue these people's lives.

Next slide.

Now, the most important thing I am going to say is these final few slides, which really relate to the long-term consequences. Up to this point, I have spoken about the short-term consequences.

The long-term consequences are an increase in cancer, an increase in teratogenic or birth defects, and genetic abnormalities which could be carried on in future generations. There are some other problems, such as damage to the thyroid gland, cataracts and sterility, which I do not have time to get into, and I am going to focus primarily on cancer.

Next slide.

Now, this slide just makes some very rough estimates, and I would urge considerable caution in accepting these data, but what we have tried to do is to project what might be the consequences of Chernobyl. And we have tried to make these projections pessimistically; that is, to err on the side of overestimating the potential consequences.

So if you look amongst the 135,000 people that Professor Velikhov mentioned were evacuated, you can see that we expect something less than 1,000 excess cancers and perhaps as many as 500 excess deaths to occur over the next 50 years, so that we would

normally expect about 20,000 of these people to develop cancer and we anticipate perhaps that 21,000 might develop cancer.

Now, the percentage is small; it is five percent, but obviously I need not tell all of you that every case of unnecessary cancer is a tragedy. And we can project these figures for the 75 million people that live in the Soviet Union or for the five billion of us that inhabit the planet.

And if you just look at the bottom columns, then, you will see that our projections—and again I would urge caution because they may be too high—but there might be as many as 10,000 or even 150,000 excess cancers and as many as 5,000 or 75,000 excess cancer deaths.

So we are dealing with a serious problem, but it is an actual fraction——

The CHAIRMAN. Those are all attributable to Chernobyl?

Dr. GALE. We are speaking about cancers that would occur because of Chernobyl. Now, if these figures were off by a factor of ten, ten times too high, then there might be only 1,000 excess cancers worldwide, but still I think that is a very serious statistic.

Next slide.

When will these cancers occur? Well, if we can judge from the atomic bomb explosions in Japan, we expect leukemia to occur within a few years after the accident. We expect the other cancers to occur after 20 or 30 years, and that is because it is young people who will develop these cancers.

Next slide.

These are the kinds of cancers we expect. Leukemia is by far and away the most important, and the other cancers are shown on this slide.

Next slide.

The long-term response to Chernobyl has to, by definition, be an international effort, and I am happy to say that the Soviets and ourselves and members of all of the countries that are shown on this slide are working together in order to accomplish this project.

Now, finally, just a word about nuclear reactor accidents and our need to prepare for them. There have been three major reactor accidents in 1967 in the United Kingdom, Three-Mile Island, and Chernobyl. That is in about 4,000 operating years, and one can use this to predict the likelihood of another accident occurring in the next ten years.

Can I have the next slide?

Now, this is a highly debated statistic; that is, how likely are we to have an accident. And I am going to say very cautiously that somewhere in the world, the likelihood of another major nuclear reactor accident in the next ten years is probably not less than 25 percent. So such an accident can occur.

Next slide.

Now, this slide is important because it just shows you—and I am coming to the end now—it shows you what happened at Chernobyl and what could happen in a worse-case scenario. WASH 14 represents a projected outcome, a worse-case scenario of a nuclear reactor accident.

And if you just look at a few of these columns—for example, if we look at immediate fatalities, there were 31 at Chernobyl, but there could be several thousand in a worse-case scenario.

If you look at the decontamination area, the second column from your right, you can see that the decontamination area in Chernobyl, as we heard, was 2,700 square kilometers, but it could be 11,000.

And the cost of Chernobyl, which is probably somewhere, in our terms, between $4 and $8 billion, could be as high as between $12 and $14 billion, or perhaps higher.

Next slide.

What should we do? What are our recommendations post-Chernobyl? Well, obviously, it is easier to prevent nuclear reactor accidents than it is to respond to them. We should in this country, and probably elsewhere in the world, have tertiary care hospitals that should be linked to reactors, and there should be a specific medical team that has responsibility for such a response.

I just put on this slide the components of this team. I do not think it is necessary to go through them; they will be in the record.

Next slide.

Now, I just want to close with the idea that, in considering Chernobyl—and I think Professor Velikhov has already alluded to this—we have to have some yardstick. What shall we compare Chernobyl to? What does it mean to lose this number of lives?

Now, if we take a very serious scenario, let us say that the Soviet Union were to lose 25,000 lives because of Chernobyl over the next 70 years. What can we compare it to? And I have just chosen three things to show you.

One is to compare it to fossil fuel; that is, if we were take the eleven percent of energy that they get from nuclear sources and replace it from coal, how many lives might that cost?

And we project, and these are very rough figures, that that might cost a million lives. Now, the difference is that the 25,000 lives that Chernobyl cost is an unpredictable outcome. There might not be another Chernobyl or there might be a Chernobyl tomorrow and it might be ten times larger.

It is a fewer number of lives, but it is unpredictable and it can have unpredictable magnitude. We can replace it by fossil fuel, but this will give us a guaranteed loss of life, and that difference is what a society has to choose between.

I would point out that in the United States over a similar period of time, we will lose about four million lives as a result of automobile accidents. And I hate to bring this up again, but if we all do not stop smoking both in the Soviet Union and in the United States, we are going to lose ten million lives in the next 50 to 70 years.

Now, I am not trying to argue that any of these things are good for you, not exploding nuclear reactors and not smoking. But in trying to decide these complex issues, we have to consider the potential impact of all of the alternatives, and in the context of an informed society we can then vote on what is the best alternative.

So let me just close, if I could, by reading a statement of something that I will file with the Committee, if I may. This will be brief.

What lessons can be learned from Chernobyl? Some conclusions are already evident. First are the inseparable benefits and hazards of nuclear energy. I suspect that when fire was first discovered, primitive man must have assumed that if this energy source got out of control, it would destroy his world. His reaction must have been similar to our reaction to Chernobyl and our fears of the impact of a nuclear reactor accident.

Man strikes a Faustian bargain with energy, whether it is with fire or nuclear energy. There is no energy without a price. That price may be contamination of the atmosphere by hydrocarbons or it may be the potential hazards of a nuclear accident.

Clearly, scientific progress will not be held back. Most scientists believe that nuclear energy, if properly exploited, will be useful. Work on the peaceful uses of nuclear energy will continue, though perhaps at a slower pace after Chernobyl.

The events of Chernobyl underscore the need fully to understand the potential risks of the use of nuclear energy. We must make every effort to prevent accidents, and we must assure our fellow citizens that we are prepared to respond to such accidents when they occur.

There are more important lessons from Chernobyl. These events reveal that any nuclear accident is international in scope. They also underscore the willingness of the international community to cooperate in the aftermath of a disaster.

Scientists from more than 20 nations contributed their efforts, many of whom disregarded political differences in an attempt to save human lives and advance scientific knowledge and prevent future accidents.

Perhaps the most important lesson from Chernobyl is that in the context of modern technologies, such as the exploration of space, such as nuclear weapons, and such as the peaceful use of nuclear energy, we live on a very small planet and we have got to find a way to work together. Nuclear energy can either work for the benefit of mankind or it can end our civilization.

Thank you.

The CHAIRMAN. Thank you very much, Dr. Gale, for an excellent presentation. I think you have become a master of changing plans at very quick notice to respond both for our Committee hearing and, most dramatically to the Chernobyl tragedy, are very, very grateful to you for a comprehensive commentary about what you were facing and what the current situation is and what potential dangers are as a result of the Chernobyl tragedy.

Could you tell us a little bit about the kind of response that you got when you were traveling there to the Soviet Union working with the Soviet medical team? What are some of your personal impressions? Were they glad to see you?

Dr. GALE. I think they were happy to see us. I think we all realized that any country would be limited in its ability to respond to an accident of this magnitude. I asked Dr. Hammer to contact Mr. Gorbachev and Mr. Gorbachev invited me to come to the Soviet Union. I felt alright at work with our Soviet colleagues.

I think it is like any battlefield situation. We were working side by side and political differences were of minor concern at that time. Now, we have tried to continue our interaction with the Sovi-

ets, and I have to say that they have been willing to continue that, and they have invited me back to the Soviet Union this Friday to actually visit Pripyat, where I hope to get a firsthand view of the resettlement of the area and follow up on these 135,000 people who I feel it is our obligation to help the Soviets follow one by one.

The CHAIRMAN. Did you actually visit Chernobyl?

Dr. GALE. I visited several times by helicopter, and I expect to be there on Monday morning on foot.

The CHAIRMAN. Could you tell us a little bit about the follow-up that has taken place with regard to Soviet authorities on the dangers of radiation to their citizens? I understand there has been a follow-up in terms of expectant mothers, for example, and whether there have been birth defects. Maybe you can tell us a little bit about it.

Dr. GALE. Well, I can only report as an American by virtue of the data the Soviets have provided to me. They have established an institute in Kiev which will be responsible for the long-term follow-up and which is headed by the Minister of the Ukraine, Romanyenko.

I am told that all 135,000 people have been registered by name or are in the process of being registered. All of the women who were pregnant at the time of the accident have been examined and the children who have been born after that have been examined.

Two delegations of Soviet scientists are on their way within the next week, really, to the United States to continue these ongoing collaborations. We hope to help the Soviets to establish the dose that these people have received using some very sophisticated laser technology which we have available at the Lawrence Livermore Labs.

So I think things are going reasonably well and scientific collaboration is continuing at a reasonable rate. It seems to us that the Soviets are pursuing this in a reasonable way.

The CHAIRMAN. Will you perform any more bone transplants or has that period passed now?

Dr. GALE. That period has passed. They would be done in the first month after the accident or not at all. Now, as some of these people develop leukemia, which they may very well, transplants will again become an issue because for many cases of leukemia, bone marrow transplantation is the treatment of choice.

We in the United States do about 2,000 a year for patients with leukemia who have not been exposed to radiation.

The CHAIRMAN. Senator Adams, we are glad to have you join us at this part of the hearing. We have had a very interesting and fascinating morning with Dr. Velikhov and Dr. Gale. We know you have listened to his testimony about some of the health and scientific implications of this tragedy on the Soviet citizenry and, to some extent, in different parts of the world.

Just before yielding to you, do you know of efforts being made by these other countries to do health assessments on what the potential danger is to them?

Dr. GALE. Well, yes. Each country has taken specific measures—the best studied one to date is Sweden. Our colleagues in Sweden anticipate that over the next 50 years, they may experience something like 200 cases of cancer as a consequence of Chernobyl.

Again, the absolute number is small, but as a physician, I regard each of these cases, as a very serious event.

The CHAIRMAN. Senator Adams.

Senator ADAMS. Thank you, Mr. Chairman. I apologize for having been at another committee hearing this morning that I could not leave.

I am very concerned about this, Doctor. Were you involved at all in any of the health studies of the clouds that went over the State of Washington, particularly over the cities of Olympia, Seattle, and so on?

Dr. GALE. I was not. I think I was in the Soviet Union at the time.

Senator ADAMS. I see. Second, have you participated since you have returned in any governmental studies regarding potential adverse health effects resulting from the operation of the Chernobyl-type—in other words, graphite core-type—reactor at Hanford, Washington?

Washington happens to be my State, in case you had not noticed from my questions.

Dr. GALE. Yes, I gathered.

I have not, but I have tried to provide to the United States government, DOE and various bodies, whatever additional information I have acquired or my colleagues have acquired. It is not part of a formal transmission from the Soviet government to ours.

Senator ADAMS. Have you participated at all in any studies with regard to the public health effects and dangers of waste disposal in both the production and the way that it is being done out of both private and defense structures here, with particular regard to the radioactive effects of trying to dispose of this and its dangers in transport?

Dr. GALE. No. I have to say that my field is as a physician and an expert in the response to these kinds of accidents and not in the physics or in waste disposal.

Senator ADAMS. I just wondered if there had been any public health type seminars that you were aware of or might have attended that would be a certainly very important part of what would be a scientific study of what has been the effect of our programs, and I mentioned the one, in particular, because it is of the same type and it has had some venting, and so on, in the past.

Dr. GALE. I think you raise an important point. I might just say that one might wonder why are we willing to invest so much energy and so much money, ultimately, in following 135,000 Soviets. That would really be the responsibility of the Soviet government.

My answer will come back to your question, which is that we do not really know the long-term consequences of exposure to low doses of radiation. We have extrapolated these consequences from the atomic bomb explosions, which are rather different.

Now, if we really want to know the health impact of the kinds of dangers you mention, we have got to know the precise relationship between exposure and cancer, for example.

And our only hope is that by helping the Soviets to follow these 135,000 people that in the long run we will know, or we may know the relationship between dose and effect, and then we then as a so-

ciety could decide whether the risks and benefits were worthwhile for any particular technology, but in this case nuclear energy, and the disposal of its waste would be part of that.

Senator ADAMS. Thank you, Doctor. That was to be my third question, was that if this was not a unique opportunity for us to determine what some of the long-term effects might be from incidents in the past where we have not had either the time period past or the attention focused on the potential effects of both the radioactive dust and its settlement and the radiation from the original incidents.

Dr. GALE. I can say as a physician I think it would be irresponsible of us not to try to learn all we could from Chernobyl. We have more nuclear power stations than the Soviets, and therefore it is our responsibility to learn all we can.

So far, we have been fortunate that the Soviets have been willing to let us participate in that.

Senator ADAMS. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you very much, Senator Adams.

In addition to the statements and exhibits of the two witnesses, there are other materials that should be made part of the record from the Nuclear Control Institute, which is concerned about nuclear power's vulnerability to terrorism, and from the National Institutes of Health's recently published study on the medical implications of nuclear war.

Dr. Gale, we are, again, grateful to you. It has been an enormously helpful insight into this whole tragedy. I want to give you the assurance that we are going to follow these flow lines, these trend lines, and we would invite you to continue to be in touch with the members of the Committee—me, in particular, and I am sure Senator Hatch, I know, is interested in it—and as these studies take place, that you share that information with us.

As I mentioned earlier, we have followed the impact of radiation effect, the health implications on Three-Mile Island and also out in Utah. We are very interested in this question. It is a matter of concern to the American people in many different communities, and it is important that we benefit from whatever information we can gain as a result of this tragedy.

I do not want to overburden you, but to the extent that you could be good enough to keep in touch with us on it, we will be glad to share your information with our colleagues on this Committee and in the Senate.

We thank you for coming, and our Committee stands in recess.

[Whereupon, at 12:30 p.m., the Committee was adjourned.]

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